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Endovascular Treatment of Chronic Splanchnic Syndrome

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Objective. *The technical and clinical outcome of endovascular revascularization was analyzed in patients with suspicion of chronic splanchnic syndrome (CSS).*
Methods. *Medical history, duplex, angiography and exercise gastric tonometry suggested CSS in 97 patients. Twenty-seven of them were treated endovascular (one patient had 3-vessel, 12 patients had 2-vessels, 14 patients had 1-vessel CSS). Five patients received previous splanchnic revascularization. Twenty-three patients (85%) had severe co-morbidity: cardiac, pulmonary or cachexia. Endovascular treatment consisted of percutaneous transluminal angiography (PTA) of the coeliac artery (CA) or superior mesenteric artery (SMA) in three and primary balloon expandable stenting in 24 patients (13 CA and 10 SMA solitary, two CA and SMA both, 31 splanchnic arteries in total).*
Results. *Three patients showed procedure related complications (11%). Mean follow-up was 19, range 2–76 months. Two patients died during follow up, both not procedure or CSS related. Five patients had no improvement of symptoms, without evidence of re- or residual stenosis. The primary clinical success was 67%, secondary clinical success was 81%. The primary patency was 81% and secondary patency was 100%.*
Conclusion. *Endovascular treatment of CSS has a reasonable outcome. It is an alternative to operative treatment, especially in patients with high co-morbidity or limited life expectancy.*

Key Words: Chronic splanchnic syndrome; Mesenteric ischemia; Atherosclerosis; Endovascular treatment; Balloon expandable stent.

Introduction

Chronic splanchnic syndrome (CSS) is defined as symptomatic single or multiple splanchnic vessel stenosis. It has to be differentiated from chronic splanchnic disease (CSD), where obliterative splanchnic vascular disease is observed, but without symptoms. The prevalence of ≥50% stenosis of at least one of the splanchnic artery origins, ranges from 10 to 24% in unselected autopsy studies and selected angiography studies.[1,2] It is assumed that abundant collateral circulation is responsible for the absence of CSS in most of the patients with CSD, hence many patients will remain asymptomatic.

The classical triad of postprandial abdominal pain, a bruit in the upper abdomen and weight loss, is observed in less than half of the patients with CSS. The clinical picture can be quite non-specific with presenting symptoms like: gastritis, stomach ulceration, gastroparesis, mild diarrhea or abdominal symptoms related to physical exercise. The diagnosis CSS should be considered in every patient with unexplained chronic abdominal complaints in combination with a significant stenotic lesion in one or more splanchnic arteries. It is widely accepted that patients with symptomatic stenosis are potential candidates for treatment.

Treatment modalities available include surgical or endovascular techniques. Vascular reconstructive surgery offers excellent short and long-term results.[3–5] Complication rates increase in patients in poor nutritional state and with serious co-morbidity.[6,7] Endovascular treatment has been used in selected cases.[8–14] Similar to developments in the management of renal and iliac atherosclerotic disease, endovascular treatment is increasing and has moved from PTA alone, to primary placement of a stent.[15–19] Currently there are no data available from randomized trials, comparing surgical and endovascular treatment. Due to low prevalence of CSS it is questionable if there will ever be any. Our technical and clinical experience with endovascular treatment of patients with CSS was analyzed in order to shed further light on this approach.

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Patients and Methods

The Medisch Spectrum Twente Hospital is a nationwide, tertiary referral centre for evaluation of patients with suspicion of CSS in The Netherlands (16 million inhabitants). A multi-disciplinary study-group formed by a vascular surgeon, gastro-enterologist and radiologist, participated in evaluation of all patients suspected for CSS.

From July 1996 to December 2002, 278 consecutive patients with the suspicion of CSS were evaluated. This evaluation consisted of gastric exercise tonometry,[20] splanchnic artery duplex ultra-sonography, multi-plane abdominal aorta angiography both during in- and exspiration and selective splanchnic artery angiography. The diagnosis CSS was made in patients with a medical history and presentation that fitted, in combination with a significant stenotic lesion in one or more splanchnic arteries confirmed functionally with gastric exercise tonometry and anatomically by duplex and angiography.

After discussion of all the results in the study-group CSS was diagnosed in 97 patients (59 patients single vessel, 33 patients 2-vessel, five patients 3-vessel CSS) and rejected in 163 patients. The remaining group of 18 patients, with a classic medical history and abnormal tonometry, but without anatomic proof for stenosis; were treated conservatively. In the 97 patients with CSS operative treatment was performed in 70, endovascular treatment in 27 patients (Fig. 1). These 27 patients are the subject of this report. Patients with a low risk for perioperative complications in combination with good long-term prognosis were selected for open surgery. While higher risk patients with a moderate to poor long-term prognosis were treated by the endovascular technique. Primary stenting with a balloon expandable stent is the preferred endovascular treatment. In short non-calcified, non-ostial lesions PTA alone was used.

The endovascular procedure was performed in the angio-suite, where the most optimal conditions for positioning and imaging were available. The procedure consisted of simultaneous Seldinger catheterization of the common femoral and brachial arteries. A calibration catheter was positioned in the abdominal aorta via the femoral artery, in order to simplify identification of the origins of the coeliac and superior mesenteric artery. After intra-venous administration of 5000 units of heparin, a balloon expandable Bridge® stent (AVE-Medtronic) was placed via the brachial artery (Fig. 2). One day before the procedure, medication with salicylates was started (calcium carbasalate 100 mg/day). Discharge, depending on concomitant disease, was planned the day after the procedure. Primary and secondary clinical success, together with primary and secondary patency rates were recorded for all patients (Fig. 3).

Results

The patients consisted of 14 men and 13 women with a mean age of 62 years (median 65, range 28–81 years). Nineteen out of 27 patients reported severe weight loss. The body mass index (BMI) was 21 kg/m^2 (range 17–28 kg/m^2). Severe cardiac and/or pulmonary co-morbidity or severe cachexia, were the main disqualifying factors for operative revascularization, and was present in 23 of 27 patients (85%). Out of 27 patients with CSS, one patient had 3-vessel, 12 patients 2-vessel and 14 patients 1-vessel stenosis (Table 1). All stenosis were ostial lesions, or within the first 3 cm of the CA or SMA. Five patients received splanchnic vascular reconstructive treatment before (four in another hospital, one was operated upon in the Medisch Spectrum Twente hospital): two patients retrograde venous bypasses to the SMA, in one patient in combination with stenting of the CA. One patient underwent an operative release of the CA and the last two patients received a stent in the CA before.

An overview of the endovascular treatment of different splanchnic arteries is shown in Table 2.

Three patients received angioplasty only; the other 24 patients underwent primary stent placement. Single vessel revascularization was performed in 23 patients (13 CA and 10 SMA); both CA and SMA revascularization in the remaining four patients. Consequently 31 splanchnic arteries received angioplasty, including stenting in 28 arteries. In hospital complications were observed in three patients (11%): one patient developed a hematoma and neuropraxia of the arm following brachial catheterization; in two other patients the stent dislodged from the catheter during angiography, necessitating operative removal from an arm and a leg. Balloon inflation was experienced as painful in some patients, especially during secondary procedures. Hospital mortality was not observed.

The mean follow-up, including duplex ultrasound was 19 months (median 14, range 2–76 months). Two patients died, due to causes unrelated to CSS or the endovascular treatment. One patient died from known lung carcinoma, the other due to multiple organ failure following gastric bleeding, 1 month after PTA of the CA, resulting in gastric resection with death 6 months after original endovascular treatment.

The primary clinical success, defined as full recovery or significant improvement of symptoms after the endovascular intervention, was 67% (18/27

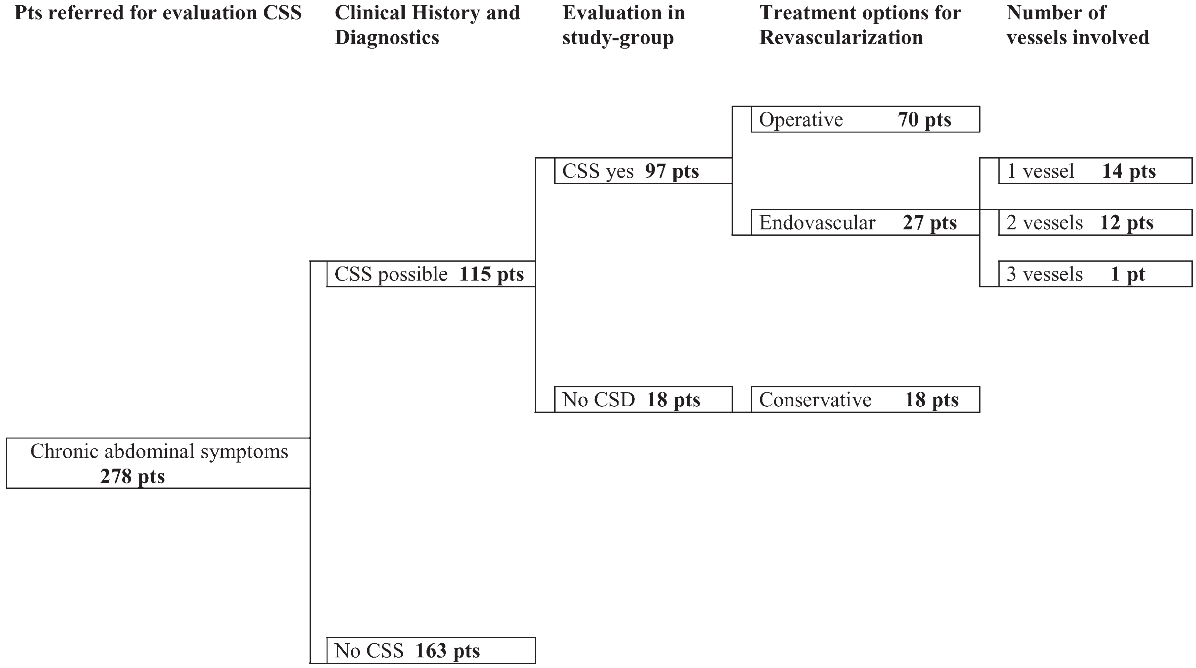

Fig. 1. Flowchart of 278 consecutive patients evaluated for the existence of Chronic splanchnic syndrome (CSS).

Table 1. Patient demographics and characteristics

Pt	Sex M/F	Age (years)	Duration symptoms (months)	Severe co-morbidity	Vessels involved			Previous treatment	Atherosclerosis (c = central) (p = peripheral)
					CA	SMA	IMA		
1	F	69	24	+	+		+	−	−
2	F	54	23	+	+	+		−	c
3	M	75	7	+	+			−	−
4	M	81	60	+	+			−	c
5	M	51	15	+	+	+		−	c
6	F	68	6	+	+	+	+	−	p
7	M	81	5	+	+			−	−
8	F	56	22	+	+			−	−
9	M	69	6	+	+	+		−	c + p
10	M	61	15	+	+	+		−	c
11	F	76	13	+	+	+		−	c
12	M	55	16	+	+	+		−	c + p
13	M	72	>27 yrs	+	+			−	−
14	F	72	16	+		+		−	p
15	F	65	7	+	+	+		−	c
16	M	57	8	+		+		−	c
17	F	35	5	−	+			−	−
18	M	70	17	+	+	+		−	c
19	F	56	15	−	+			−	−
20	M	59	26	+		+		−	−
21	M	57	>48	+		+		SMA bypass	−
22	F	67	7	+	+	+		−	c + p
23	M	69	12	+	+			−	p
24	F	42	4	+	+	+		SMA bypass + stent CA	−
25	M	68	23	+	+			PTA + stent CA	p
26	F	57	>60	−	+		+	PTA + stent CA	c
27	F	28	48	−	+			Release CA	−

Pt, patient; M, male; F, female; CA, celiac artery; SMA, superior mesenteric artery; IMA, inferior mesenteric artery; +, means present; − means absent.

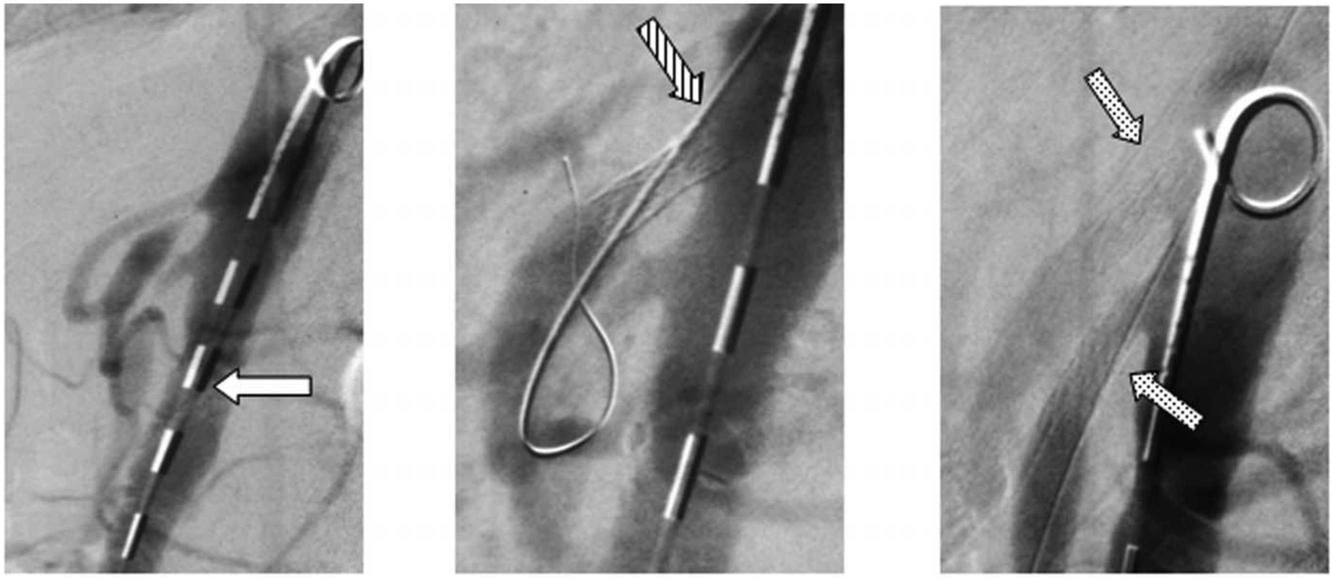

Fig. 2. Stent placement endovascular stent placement in the celiac and the superior mesenteric artery in a patient with 2-vessel CSS. The procedure consisted of simultaneous Seldinger catheterization of the common femoral and brachial artery. Following heparinization two balloon expandable Bridge® stents were placed in the SMA and CA.

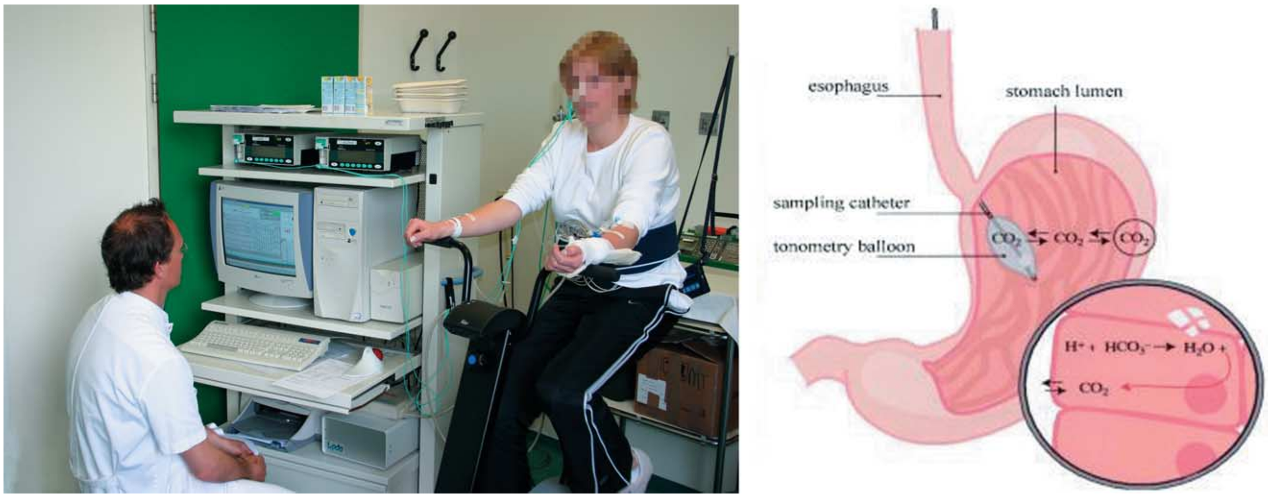

Fig. 3. Gastric exercise tonometry.

patients). Re-intervention was performed in five patients (19%), all anatomically successful, by the endovascular (4) or open surgical (1) technique. Three patients underwent a redo-PTA of a stent placed in the CA, one patient redo-PTA and stent placement of the SMA and CA, and one patient was revascularized operatively after occlusion of a retrograde venous SMA bypass and a CA stent. One of the patients remained symptomatic following re-intervention.

Secondary clinical success summarized clinical outcome after primary (18 patients) and re-interventions (four successful patients out of five re-interventions) and was 81% (22/27 patients). Five patients claimed no improvement but duplex and tonometry did not show any re- or residual stenosis.

The primary patency, functional revascularization of an artery, without any re-interventions, was 81%. Twenty-five out of a total number of 31 treated arteries were primarily patent. Secondary patency, functional revascularization of arteries, including the effective re-interventions was 100% (31/31 arteries). Although five patients remained symptomatic, their reconstructions were patent.

Discussion

The present study showed that patients, unfit for operative revascularization benefit from endovascular treatment in more than 80% of cases, with an acceptable complication rate and without procedure or CSS related mortality. The anatomical results in short term follow up were good, especially if secondary endovascular procedures were included. The less satisfying clinical result in this series was a matter of proper patient selection, because in all five patients without improvement of symptoms, the anatomical revascularization was successful and the gastric exercise tonometry normalized. This indicates that the pre-intervention symptoms were not caused by insufficient splanchnic circulation. Series including only patients with typical 'angina intestinale' reported the best clinical results.[4] With surgical revascularization, excellent patency is achieved, but the overall complication rate of 29%, and mortality up to 7% in operative procedures gives rise to concern.[18] In this light endovascular treatment of CSS is a fair alternative to surgical revascularization in selected patients. Moreover, endovascular treatment could delay the necessity for surgical revascularization, until severe cachectic patients were in a better condition for undergoing a large operation.

Duplex of the splanchnic arteries visualizes anatomy and flow in the CA and SMA as well as the upper abdominal aorta. Splanchnic artery duplex is technically possible in 85% of patients. Flow should be measured during in- and exspiration. Different cutoff points are used to identify stenosis during breathing. However, the clinical impact of a stenosis seen with duplex is unclear. MRA and CTA enable three-dimensional visualization of splanchnic arteries and veins. Digital subtraction angiography, however, remains the gold standard imaging technique for detection and classification of (severity of) stenotic lesions in splanchnic arteries. Apart from a frontal view of the abdominal aorta, it is crucial to obtain lateral views of the splanchnic arteries, showing their origins during in- and exspiration. This is the only way to diagnose coeliac artery compression. Selective

Table 2. Treatment, results and patency

Patient	Previous treatment	Treatment				Primary clinical success	Re-intervention	Secondary clinical success	Complications	Follow-up (months)	Comment
		PTA		Primary stenting							
		CA	SMA	CA	SMA						
1				+		−	−		Hematoma arm Neuropraxia	6	No objective stenosis
2				+	+	+	−		−	10	
3				+		+	−		Stent loss leg	27	
4				+		+	−		−	7	
5					+	+	−		−	26	
6					+	+	−		−	17	
7				+		−	−		−	50	No objective stenosis
8				+		+	−		−	33	
9					+	+	−		−	23	
10				+	+	+	−			6	Died GI problem
11					+	+	−		−	14	
12					+	+	−		−	5	
13				+		+	−		−	5	
14					+	+	−		−	7	
15					+	+	−		−	3	
16					+	+	−		−	36	
17		+				+	−		−	24	
18		+	+			+	−		−	2	Died lungca
19				+		−	−		−	76	No objective stenosis
20					+	+	−		−	55	
21	SMA bypass				+(bypass)	+	−		−	8	
22		+	+			−	Re − PTA + stent CA + SMA	+	−	26	
23				+		−	Re-PTA + re-stent CA	+	−	13	Wrong position primary stent
24	SMA bypass + stent CA			+		−	Bypass CA	+	−	8	
25	PTA + stent CA			+		−	−		−	2	No objective stenosis
26	PTA + stent CA			+		−	Re-PTA + stent CA	+	Stent loss arm	9	Primary stent fracture
27	Release CA			+		−	Re-PTA CA	−	−	7	No objective stenosis

+, means present; −, means absent; GI, gastro-intestinal.

angiography shows collateral circulation and is essential in planning definitive treatment.

Tonometry measures the carbon dioxide level. With gastric mucosal ischaemia CO_2 will accumulate. The tonometer, a nasogastric catheter with a balloon connected at its tip, is positioned intra-gastric and connected to a modified capnograph. With ischaemia, the local pCO_2 level will increase, compared to the pCO_2 in the circulation, causing a gradient. The level of ischaemia is represented by the pCO_2 gradient (Fig. 2). Mucosal ischaemia is detected after a moderate exercise test.[20] In our experience gastric exercise tonometry has proved itself a cornerstone diagnostic tool as a functional test for mucosal perfusion in CSS patients. Proper patient selection using gastric exercise tonometry as functional test enables the differentiation between CSD and CSS. However, selection remains an issue since it is still not clear if, and to what extent, abdominal symptoms represent CSS, let alone if intervention is indicated.

Angioplasty of splanchnic arteries was first reported by Furrer and coworkers in 1980.[8] During the past 23 years, only small series have reported on angioplasty alone or in combination with various types of stents.[9–19] Most reports are unclear on patient selection and number of stenotic lesions revascularized. Analogous to renal artery disease, primary stenting is the preferred endovascular treatment in the case of calcified ostial lesions. A balloon expandable stent appears to be the best option because of the high radial force resistance of such types of stents. Two stents were lost during placement. This is inherent to the type of balloon expandable stent that was used. A new generation of balloon expandable stents, with smaller diameters, more flexibility, better fixation to the catheter and stronger radial force, has the promise of further improvement of endovascular treatment of CSS. The series does not report on endovascular treatment of occluded splanchnic arteries. Recanalisation of longstanding occlusions is risky as perforation and outflow dissection may result. Pinpoint stenosis were successfully treated as long as the thinnest wire available could get through the stenosis. Long stenosis can be treated as long as relevant branching vessels do not become overstented. The coeliac artery compression syndrome is not eligible for endovascular intervention, since the extraluminal tight compression of the CA by the arcuate ligament is not durably pushed aside with any type of stent. The use of a transfemoral catheter is not obligatory, but the calibrated catheter facilitates exact positioning of the stent. Also, it is possible to obtain contrast imaging after stent placement with the wire in situ. Some complications of endovascular treatment are related to the entry in the brachial artery, which may be reduced by ultrasound guided arterial puncture. The solitary femoral approach is now used more often; however unlike the more horizontal renal ostia, the CA and SMA sometimes angle sharply with the aorta, making a distal approach impossible for precise positioning of a rather stiff stent. There were no patients with acute or sub-acute splanchnic ischaemia included in this series.

In general there is a strong feeling that in this group of patients the splanchnic circulation should be revascularized with primary stenting if possible, in order to buy time for adequate diagnostic work up and improvement of the physical and alimentary condition of the patient involved. This should be considered when operating on patients with acute on chronic splanchnic ischaemia, because a significantly higher mortality is observed in patients with a BMI of less than 19.0 kg/m^2. In case of ongoing peritonitis a laparoscopy or laparotomy is advised to assess the existence of transmural necrosis.

CSS is encountered infrequently. Well-known large institutions report only limited numbers. Therefore, few clinics will accumulate sufficient case material to develop principles of treatment based on level 1 evidence. Moreover, literature describing CSS does not include large-scale natural history studies, nor randomized or controlled clinical trials.[21]

The present study suggests that the endovascular treatment of CSS is low risk, technically challenging and has reasonable long-term outcomes. We recommend endovascular treatment for CSS especially for those patients with a high co-morbidity or a short life expectancy.

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